PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2014

Purdue Utility Project

Agricultural & Biological ENGINEERING

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Introduction

Problem Statement:

- An affordable and reliable form of transportation is lacking in many rural communities in Sub-Saharan Africa
- The team has been tasked with optimization of the PUP driveline and frame for manufacturability, safety, and performance

Background:

- Purdue has partnered with ACREST, a NGO located in Cameroon to provide an affordable vehicle for local transportation of people, water, crops, and supplies
- Local road conditions limit transportation
- Current motorized transportation options incur large capital costs and maintenance costs
- The PUP can carry 2000 lbs, traverse rough roads, and is manufactured locally in Africa, making it affordable to the community
- Using only locally available parts and materials allows the PUP to be a sustainable vehicle for future manufacturing in the micro-factory setting

Impact on Society

- Team will travel in May to reproduce design in Cameroon using only locally available resources
- The PUP will be used on a day-to-day basis by ACREST hauling people, food, water, supplies, etc.
- The vehicle will reduce small-holder farmer labor challenges and improve productivity and food security
- Reproducing this design locally on a micro-factory scale creates sustainable employment opportunities

Multiple PTO attachments, including pumping water, provide higher value to stakeholders

Project Goals

- Optimization of truss-style frame to reduce total number of parts and decrease CG by lowering height of bed
- New engine placement to prevent theft, reduce noise & emissions to operator
- Develop a high/low gearing option for transportation or agricultural mechanization
- Explore alternative clutching mechanisms for ease of manufacturability in Africa
- Manufacture prototype to test at Purdue and to compete in an endurance event

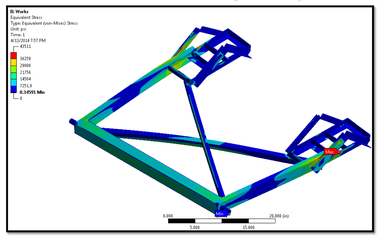
Alternative Solutions

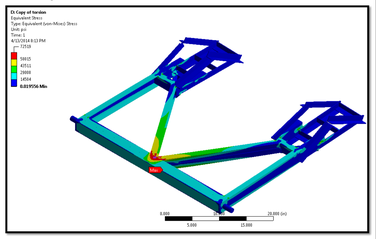
Engine Placement:

- Engine configurations under the driver's seat, in the cargo bed, and directly in front of the transmission were explored
- Criteria for safety, noise, and theft prevention were considered for final choice

Trailing Arm:

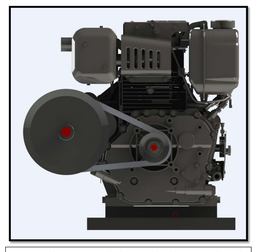
- V-arm and X-arm design compared, X-arm experiences less concentrated stress



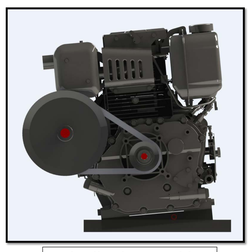


Clutching Mechanism:

- Tilting the engine to decrease the center to center pulley distance was tested and belt continued to slip while experiencing heavy loads under full tension



No slip condition (full tension)



Belt slipping position

Final Drive Options

Gear	Vehicle Speed (mph)	Tractive Force (lbf)
High Option		
1st	5.1	997.9
2nd	8.6	592.7
3rd	13.9	368.6
4th	20.1	254.0
REVERSE	4.2	1204.9
Low Option		
1st	3.4	1496.8
2nd	5.8	889.0
3rd	9.3	552.9
4th	13.4	381.1
REVERSE	2.8	1807.3

Cost Analysis

Items	Cost
Frame	
Angle iron (15 pieces, 6 meters each)	$300.00
Plywood	$75.00
Driveline	
1989 Toyota Pickup Truck for parts -Transmission, Driveline, Rear Axle, Mic. Parts	$200.00
10 HP Diesel Engine	$625.00
Rim & Tires	$ -
Suspension	
Front Strut – Ford Taurus	$ -
Springs (4)	$60.00
Shocks (2)	$50.00
Driver Ergonomics	
Brake cylinder and lines	$60.00
Lights, driver controls, handlebars, pedals	$30.00
Miscellaneous	
Misc. Components/Tools/Supplies	$275.00
Total	**$1675.00**

Final Design

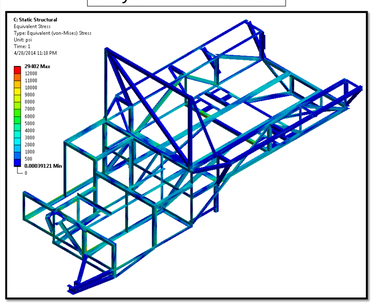
- Frame made entirely from a common size angle iron
- Bed lowered 3.7 inches (Lower center of gravity)
- Trailing arm length shortened 11 inches
- Roll stiffness increased by moving springs farther from roll center
- Engine under passenger seat to reduce emissions and noise to operator
- Clutching mechanism utilizes pinned angle iron linkages and idler pulley system

Vehicle Specifications

Wheelbase	103 in
Vehicle Length	144 in
Vehicle Width	60 in
Cargo Bed Volume	21.5 ft^3
Unloaded Weight	1240 lbs
Rated Payload Capacity	2000 lbs
Engine	10 HP single cylinder diesel engine
Transmission	4 speed with reverse, (1989 Toyota truck)
Clutch	angle iron linkage with idler pulley
Rear Differential	3.071:1 reduction (1989 Toyota truck)
Front Strut	Ford Taurus strut with disk brakes
Rear Suspension	4 coil springs (115 lb/in each) & 2 shocks

PUP assembly with 3 55 gallon water drums

Fully loaded frame FEA



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